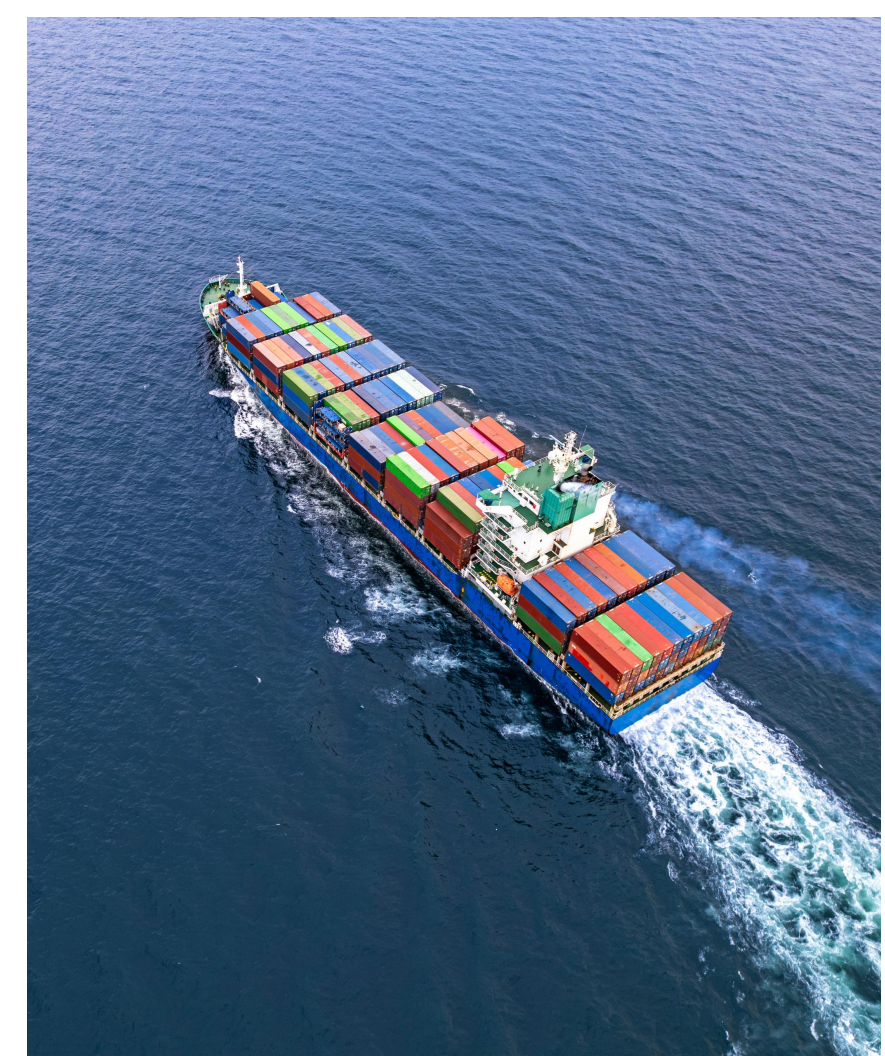




MARINE BIOFUELS WEBINAR: Sailing Towards a Sustainable Future



'Indian maritime biofuel landscape and scientific advancements in
maritime biofuels'

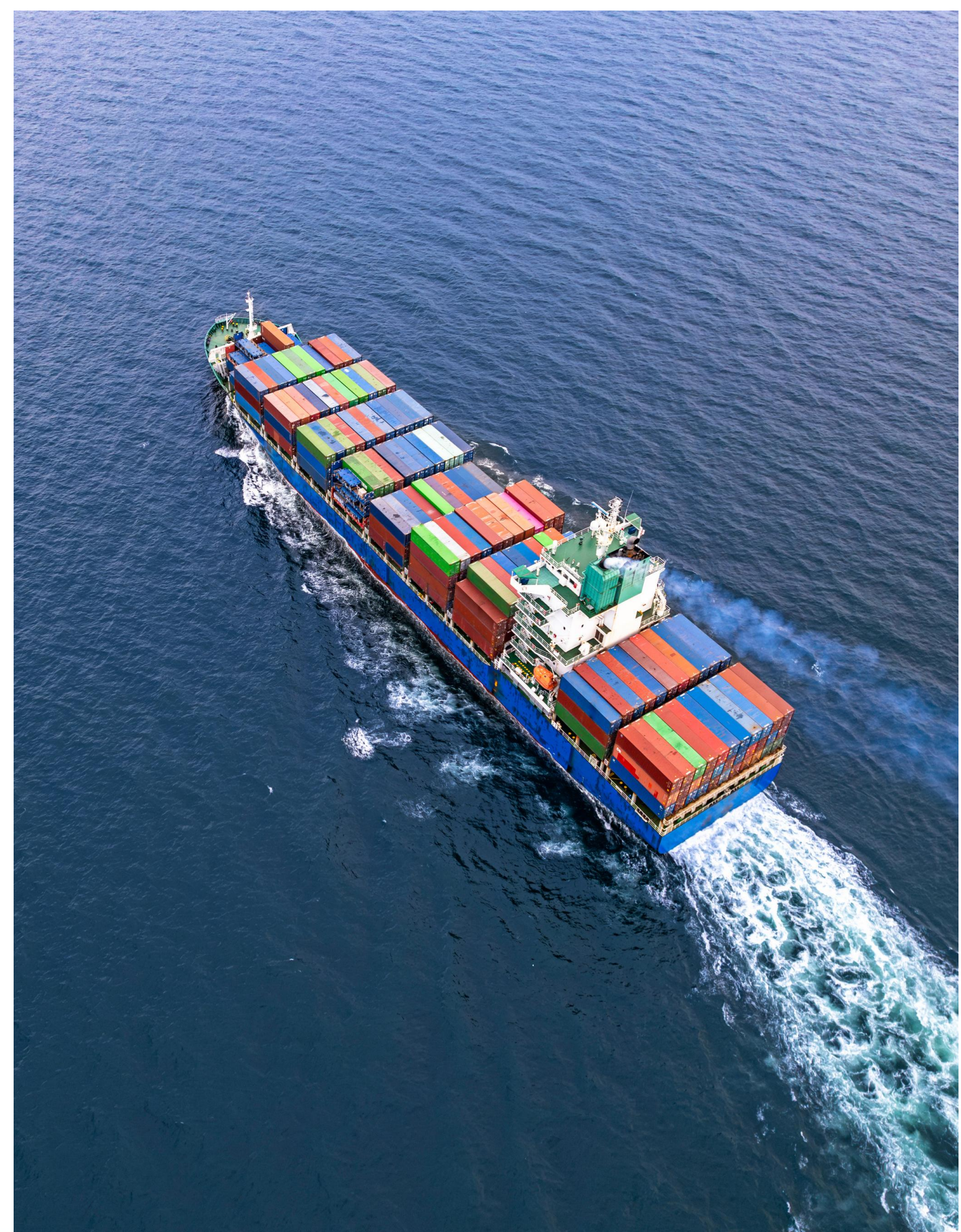
Dr. Sanjukta Subudhi (ssubudhi@teri.res.in)

26/August/2025

THE ENERGY AND RESOURCES INSTITUTE (TERI), India

CONTENT

- ✓ About TERI
- ✓ Indian Maritime landscape and Net zero goal
- ✓ List of Drop in biofuels
- ✓ Green Initiatives on Adoption of drop in Biofuels in Indian Maritime sector
- ✓ Harmonization of Biodiesel standard

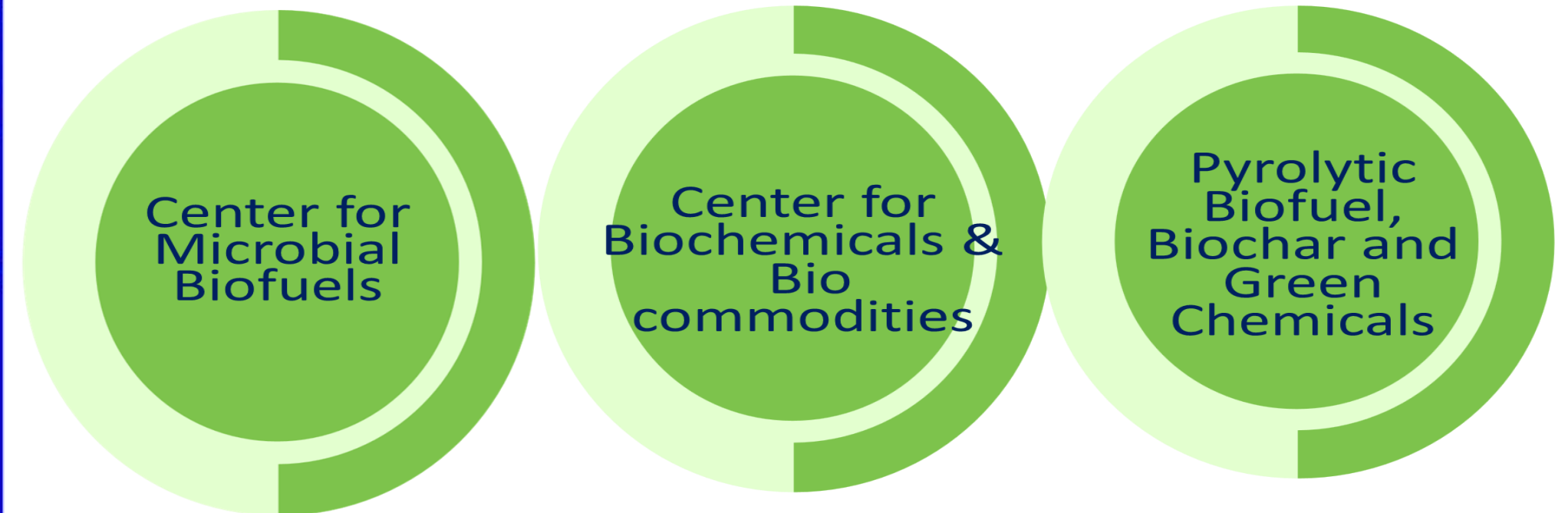
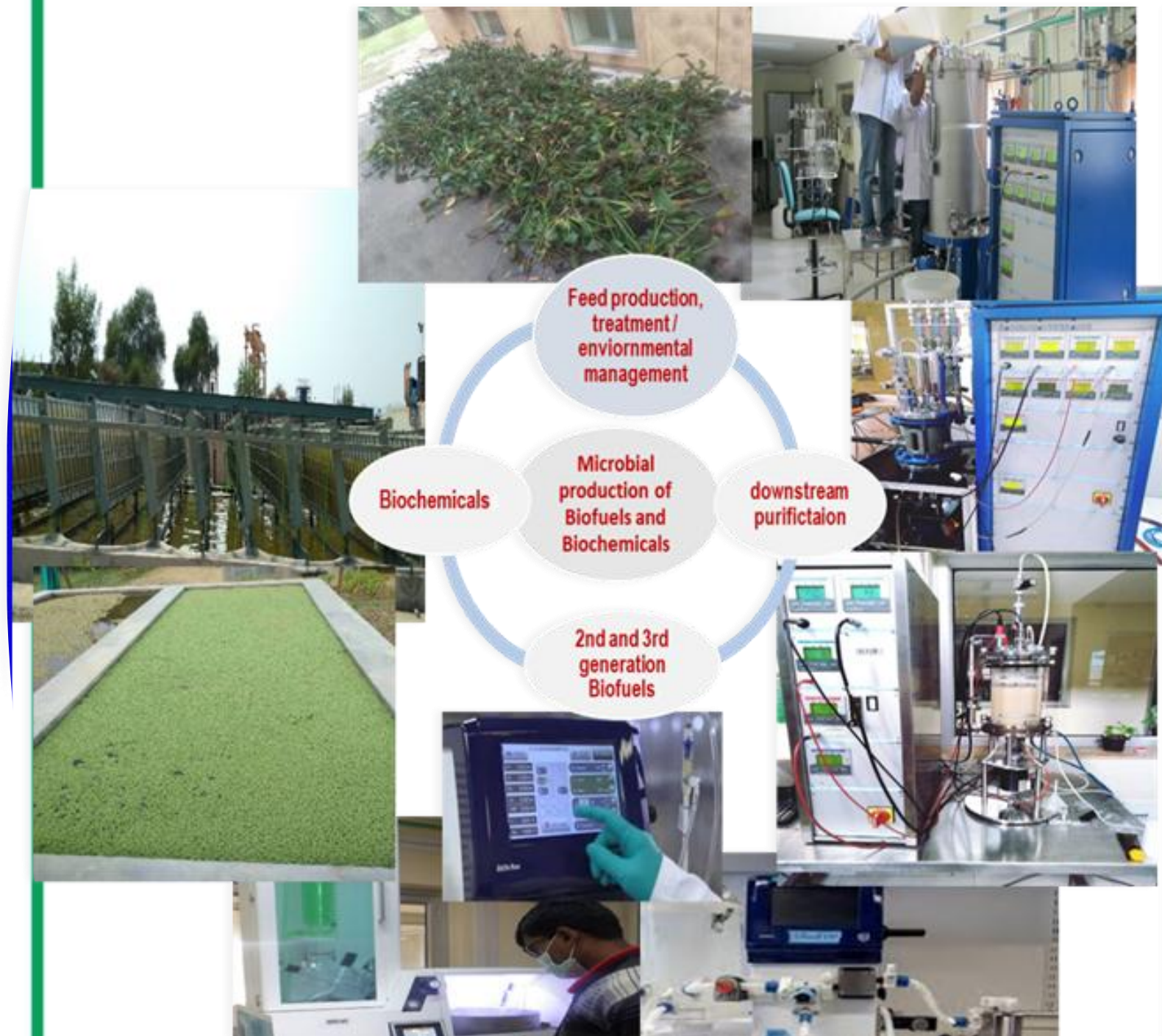


The Energy and Resources Institute (TERI)

- ✓ The Energy and Resources Institute (TERI) is an independent, research organization, headquartered in New Delhi, with regional centers in Gurugram, Bengaluru, Guwahati, Mumbai, Panaji, and Nainital.
- ✓ TERI is powered by a 1,000+ multidisciplinary team of scientists, engineers, economists, and sociologists
- ✓ Over five decades, TERI has established itself as a research leader, developing evidence-based, science-backed interventions
- ✓ Our work spans cutting-edge innovations in renewable energy, Green shipping, Biofuels, climate change and air quality, water, sustainable agriculture, sustainable infrastructure,
- ✓ As a think tank, TERI has aligned itself with global and national priorities, including India's ambitious net zero targets,



The Energy and Resources Institute: Advanced Biofuels research



India's Maritime Landscape



- ✓ India has a 7,500 km long coastline with 12 major and 200+ non-major ports, making it one of the world's largest maritime nations.
- ✓ Around 90% of nation's trade volume is carried by sea, highlighting this sector's significant contribution to India's economic growth. India has taken proactive measures, such as the Sagar Mala Program, National Waterways Act, and Inland Vessels Bill, to foster the development of this sector.
- ✓ With strategic geographic positioning, India aspires to be a global shipping and logistics hub, serving as a trade gateway for Asia and beyond.
- ✓ Total marine fuel consumption by Indian ships accounted for 1.24 million tonnes (2022), comprising HFO Heavy Fuel Oil), MDO (Marine Diesel Oil), and MGO (annual energy consumption of 55.8 Quadrillion Joules (QJ).
- ✓ HFO/MDO/MGO demand is projected for 1.43 million tonnes in 2030. The long-term trajectory expected for a gradual decline in conventional fuel use, replaced by green fuels, LNG, hydrogen, ammonia.

India's Commitment to Sustainable Maritime Development

Vision 2047: Ports of the Future

- The Maritime India Vision 2047 sets a roadmap for world-class, green, & digital ports.

- ✓ India's shipping sector has set ambitious goal to reduce carbon footprint with a target to achieve net zero goal by 20270.
- ✓ Aims to achieve net zero emissions at all major ports by 2047
- ✓ Decarbonization strategy:
 - To reduce Green House Gas emissions through use of mix of green fuels; Biofuels, Green hydrogen, Green ammonia and LNG and synthetic fuels including methanol (bio and E-methanol)



National Center of excellence on Green Ports and Shipping (NCoEGPS)



Ministry of Ports, Shipping and Waterways (MoPSW), Government of India, established **National Centre of Excellence for Green Port and Shipping (NCoEGPS)** at The Energy and Resources Institute (TERI).



(i) Paradip Port Trust (ii) V. O. Chidambaranar Port Trust (iii) Deendayal Port Authority (iv) Cochin Shipyard Limited

- To promote carbon neutrality and the circular economy (CE) in the Indian maritime industry, this center conducts a variety of studies on policies and regulations that support green ports, green shipping, and the blue economy, as well as alternative technologies.



Wind Energy



Bio-Fuels



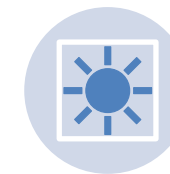
Fuel cell for Long Haul Shipping



Hydrogen Storage Tanks



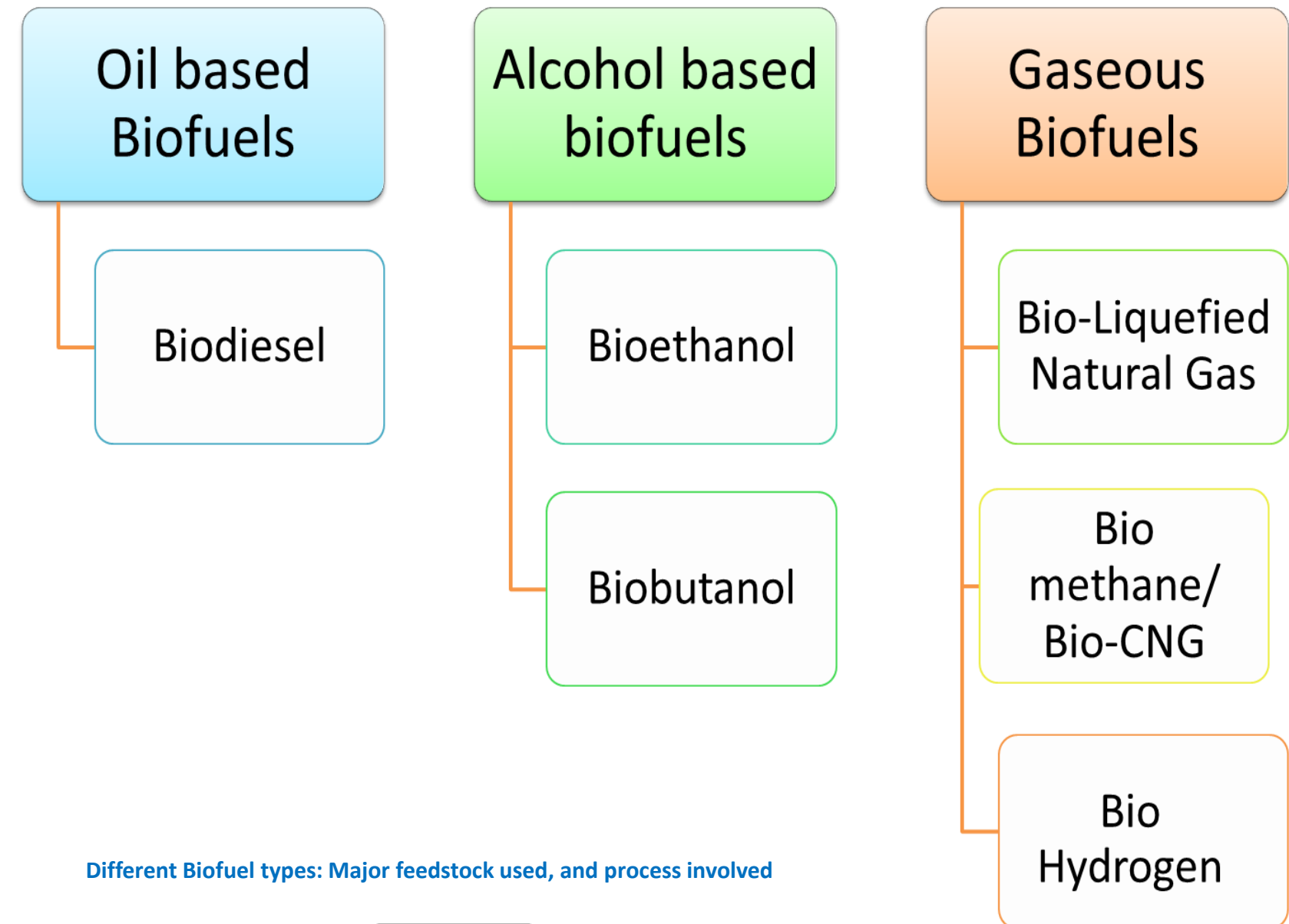
Green Ports



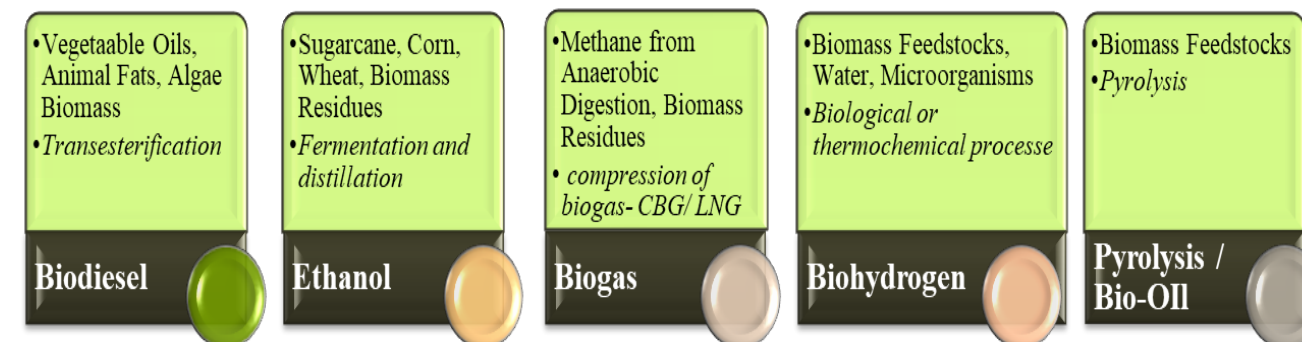
Solar Power

India's Maritime biofuel Landscape

- ✓ India's is promoting green shipping initiatives including use of biofuels, green hydrogen and ammonia
- ✓ Liquid and gaseous biofuels such as; Biodiesel, bioethanol, bio-butanol, Bio-methanol, bio-methane/ bio-CNG, biohydrogen and bio-LNG, have great potential for adoption in maritime transportation. **IMO frameworks encourage India to scale LNG and biofuel adoption in the 2030 horizon**
- ✓ Liquid biofuels are '**technologically ready**' drop in fuels for existing engines and do not require retrofitting, (can be produced from renewable biobased resources/ biomass).
- ✓ Biodiesel (oil based liquid biofuel) has similar properties like that of conventional marine fuels and thus can be **used directly as drop in fuel for blending in marine fuel**



Different Biofuel types: Major feedstock used, and process involved



Drop-in Biofuels

Drop-in biofuels are liquid bio-hydrocarbons that are functionally equivalent to petroleum fuels and are fully compatible with existing petroleum infrastructure”.

Characteristics: drop-in biofuels generally consist of a mixture of many different types of hydrocarbons, the properties of which, just like petroleum fuels, are typically characterized by the functional characteristics of the mixture, such as distillation profile, viscosity, acidity, etc.

Production Process: drop-in” biofuels can be produced, continue to be summarized in the four broad categories below:

- Oleochemical,
- Thermochemical,
- Biochemical, and
- Hybrid pathways

Marine Diesel & Renewable Diesel

Fuel property	MDO (ISO 8217 DMB)	MGO (ISO 8217 DMA)	RMA10 Diesel Fuel	Diesel fuel ASTM D975 (Elgharnawy et al., 2021)	Biodiesel ASTM D6751(Elgharnawy et al., 2021)	Diesel	FAME Biofuel	Soybean Methyl ester oil Sme (B20)	Jatropha Biodiesel (B20)	Spirulina biodiesel (B20)	Waste Plastic Pyrolysis oil (wppo) B20	LNG (Sagin et al., 2023)	Petroleum Gas (Sagin et al., 2023)	Hydrogen (Sagin et al., 2023)	Mixture of alcohols (methanol and ethanol) (Sagin et al., 2023)	Ethanol (Wang and Li, 2022)
Viscosity at 40 °C (sSt)	2 to 11 (mm ² /s)	2 to 6 (mm ² /s)	12	2.5	1.9-6	0.003 (Pa.s)	15	0.0041 (Pa.s)	0.0048 (Pa.s)	0.0036 (Pa.s)	0.017 (Pa.s)	-	-	-	-	1.2 (Mpa.s)
Density at 15 °C (kg/m ³)	<900	<890	865	850	-	830	850	839.6	839.234	836.17	826.98	0.7 (gas)	1.8-2.5 (gas)	0.1 (gas)	790-800	790
Sulphur content (%)	-	-	0.09	10(ppm)	500 (ppm)	0.025	0.02	0.0011	0.0024	0.0014	0	-	-	-	-	-
Calorific value (MJ/ kg)	42	-	-	45	37.3	42.5	-	41.39	42.53	42.28	43.29	50	47.5-48.5	120-140	22.5	26.8
Cetane number	>40	>35	-	40-55	65	48	-	48.68	52.7	51	51	-	-	-	-	8

Renewable/ Green Diesel

Fuel property	RMA10 Diesel Fuel	FAME Biofuel	Diesel	Soyabean Methyl ester oil Sme (B20)	Jatropha Biodiesel (B20)	Spirulina biodiesel (B20)
Viscosity at 40 °C (sSt)	12	15	0.003 (Pa.s)	0.0041 (Pa.s)	0.0048 (Pa.s)	0.0036 (Pa.s)
Density at 15 °C (kg/m ³)	865	850	830	839.6	839.234	836.17
Sulphur content (%)	0.09	0.02	0.025	0.0011	0.0024	0.0014
Calorific value (MJ/ kg)			42.5	41.39	42.53	42.28
Cetane number	-	-	48	48.68	52.7	51

Indian Maritime Landscape: Initiatives Adoption of biodiesel in maritime transportation

- Considering the IMO's Net zero goal, Directorate General of Shipping (DGS) in India, issued Merchant Shipping Notice No. 16 of 2023, in November 2023 for use of biofuels and their blends on Indian Ships.
- DGS permits Indian ships to use biofuels, and their blends as drop in fuels. Additionally, this notice specifies specifications for liquid drop-in biofuels that are compatible with heavy fuel oil (HFO), light diesel oil (LDO, DMB), and marine gas oil (MGO).

Requirements biofuel and its blends supplied to Ships

Biofuels	Standard	Parameters
Biofuel Blend	ISO 8217 (MARPOL ANNEX VI)	❖ Lubricity ❖ Oxidation stability ❖ Kinematic viscosity ❖ Cold-flow properties only for biofuel component ❖ Water content ❖ Acid number ❖ BDN shall incorporate only density, viscosity, water content, Sulphur, flash point and acid number.
FAME biodiesel and blend	EN 14214 Liquid petroleum products	
Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels standards	ASTM D6751 Standard Specification	
HVO biofuels and biofuel blends	EN 15940 Automotive fuels	

For liquid biofuel as drop in fuel, flash Point recommended by DG shipping:

- ❖ **Not less than 60°C.**
- ❖ determined by a closed cup test in accordance with [ISO 2719](#)
[Determination of flash point – Pensky- Martens closed cup method.](#)
- ❖ [Bunker Delivery Note](#) should state the flash point of biofuel used

Sustainability Certification

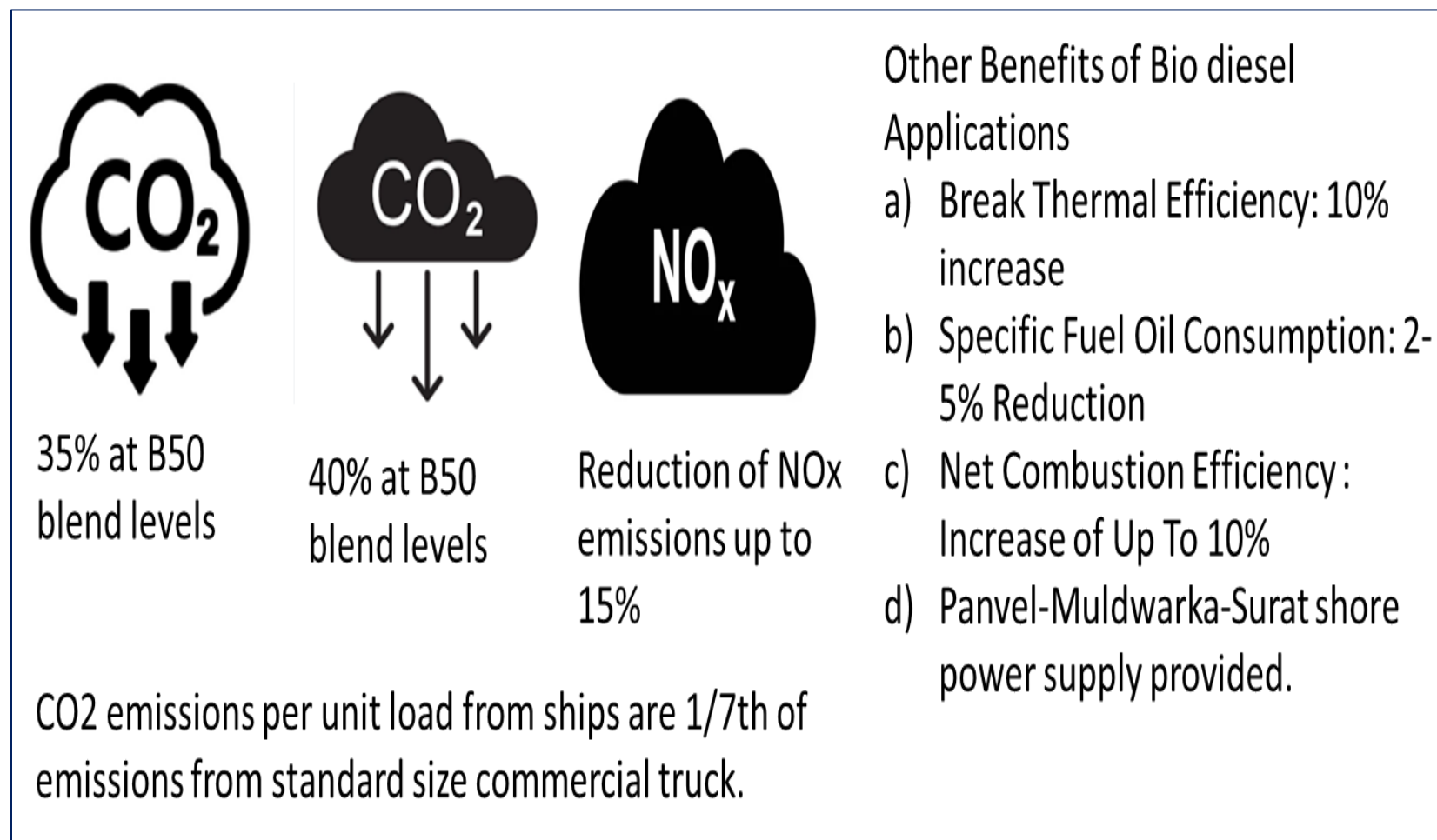
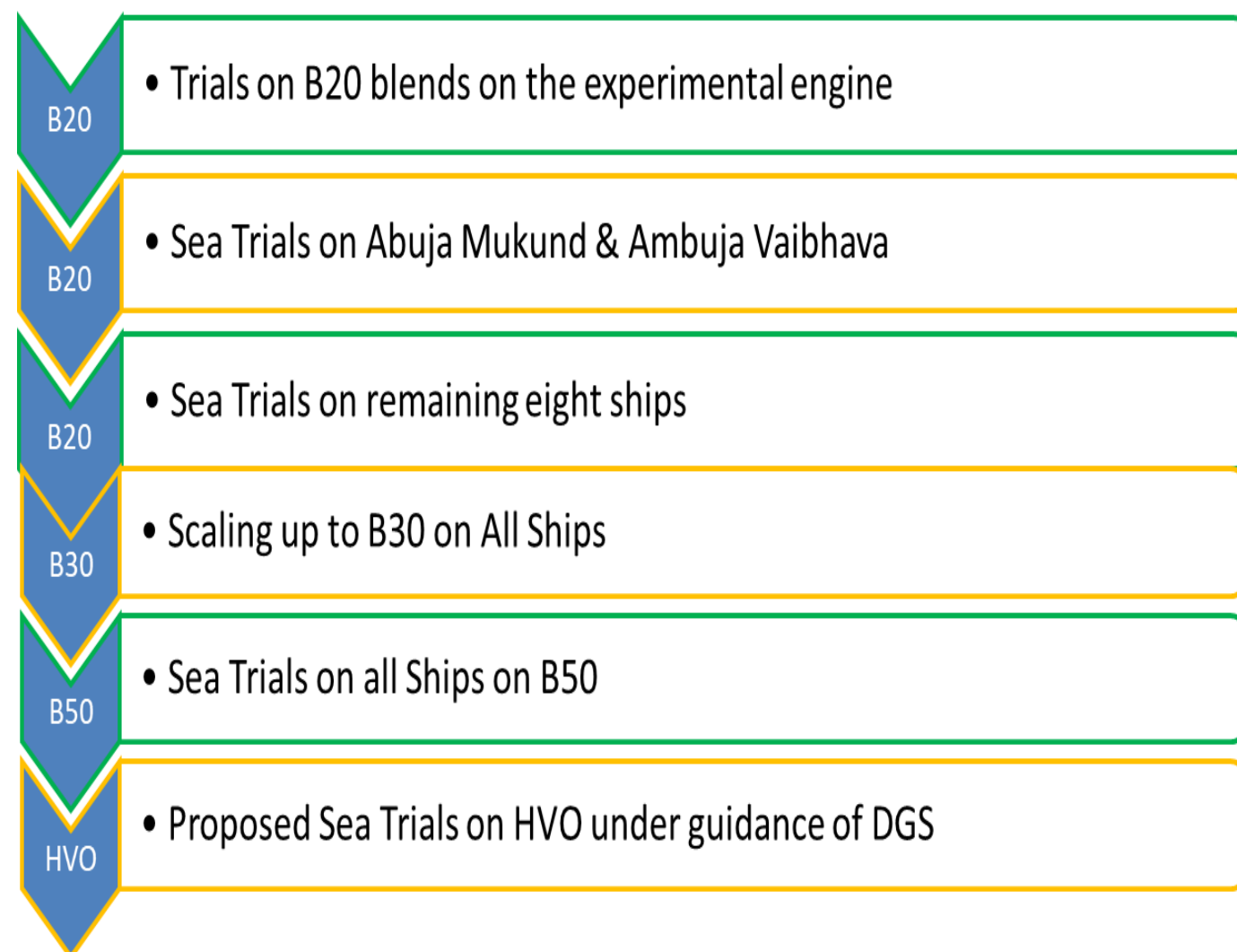
- ❖ **No biofuels shall be supplied to ships in unblended or blended form without having been certified** by an international certification scheme, meeting its sustainability criteria.
- ❖ **A Proof of Sustainability or similar documentation mentioned above should be provided** along with the Bunker Delivery Note

Biofuel blend trial case studies

Under the directives of DGS Biodiesel blend trial (B20-B-50) studies were conducted by two major shipping companies of India;

- ✓ Ambuja Shipping Servies Ltd. (Ambuja Cement) and
- ✓ Great Eastern Shipping Co. Ltd.,
(in coordination with Indian Registrar of Shipping).

Case studies on biodiesel blend trial done by Ambuja shipping services Ltd. (ASSL)



Impact of B30 blend trial on GHG emission reduction and engine performance

Case studies on biodiesel blend trial done by Great Eastern Shipping Company Ltd. (GE)

BIOFUEL Blend trial

- GE did India's first trials on an MR tanker in international waters using biofuel Blended VLFSO (B20 - derived from UCO).
- No challenges were faced during the trials.

Impact:

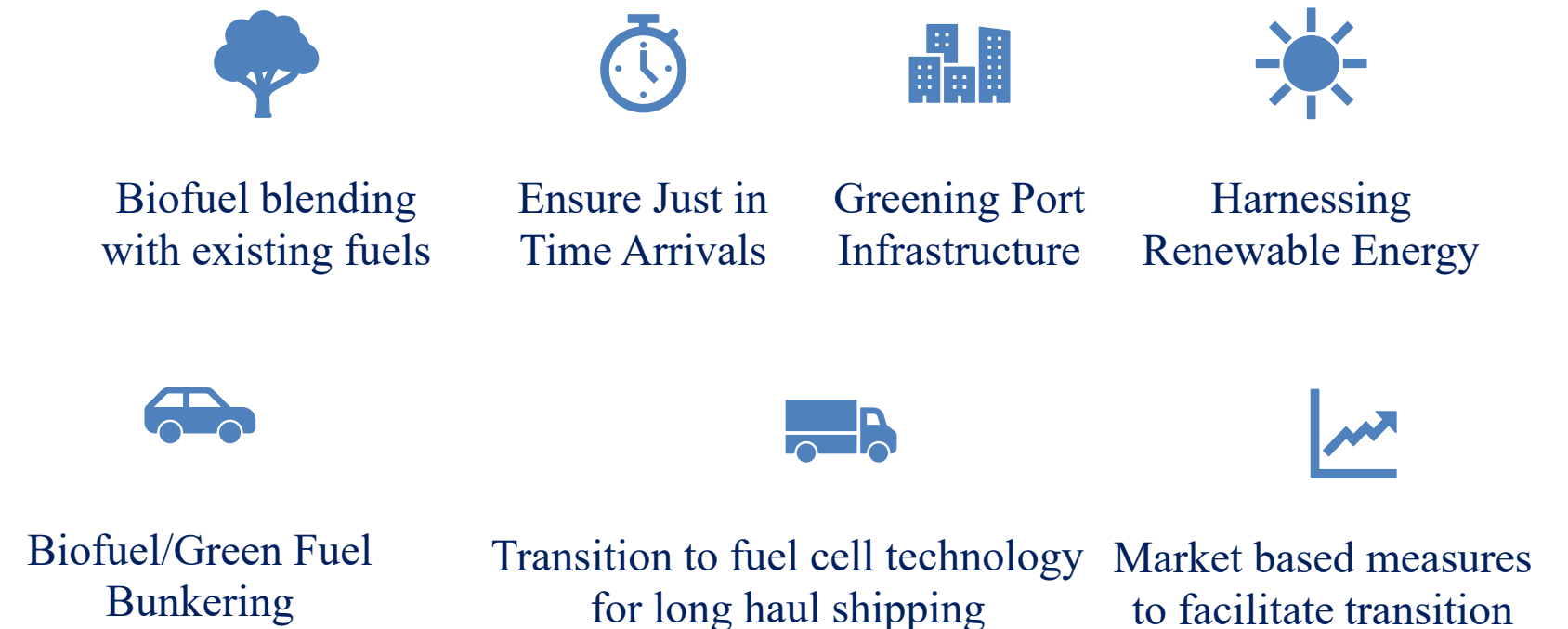
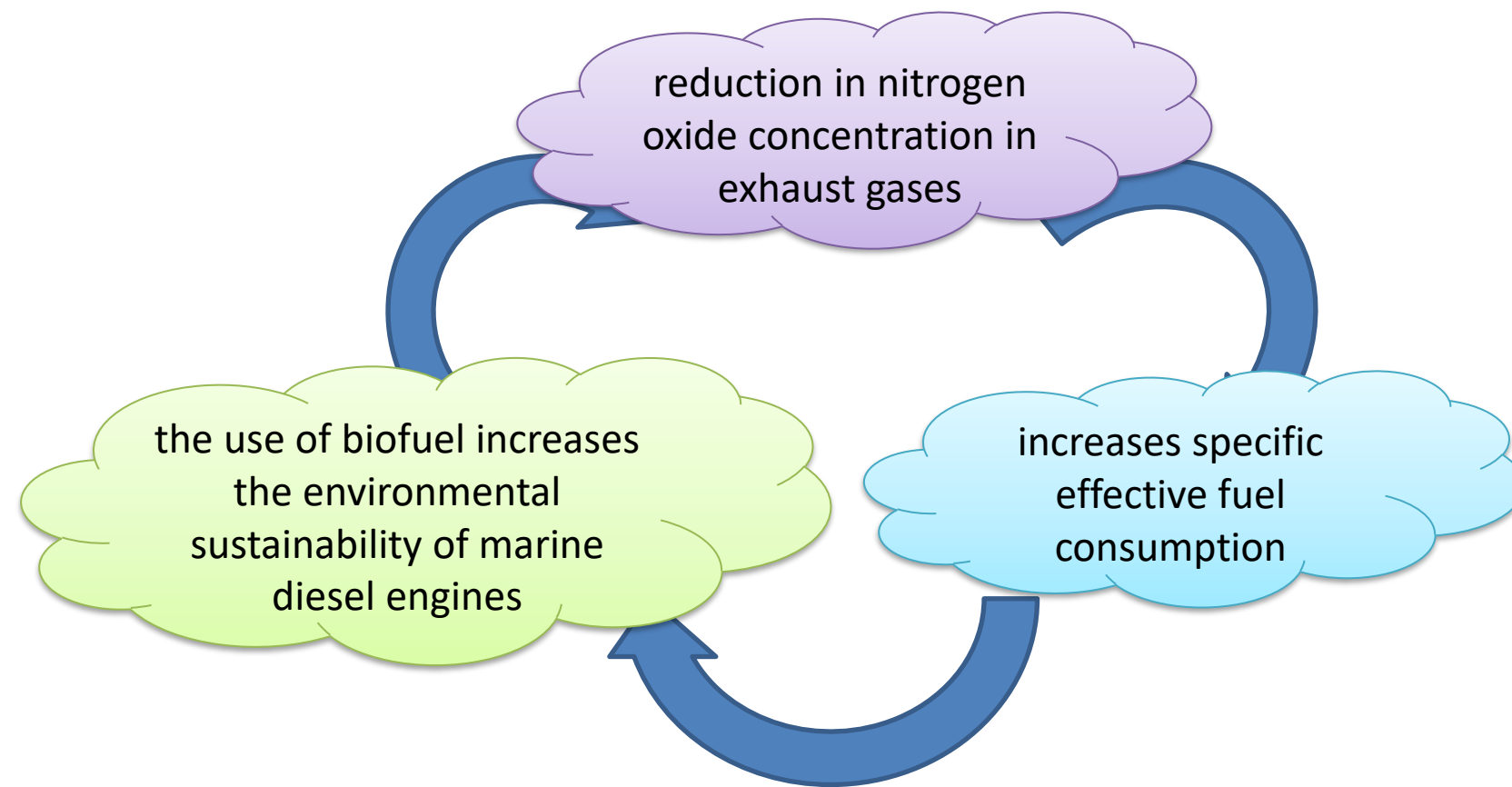
- CO2 Emission Reduction 80-90% compared to VLSFO /LSMGO. (depending on Blend Ratio)
- Can be used on all engines and fuel systems with less or no modification and expenditure.
- Faster implementation compared to all options with hardly any downtime for ships.

Results



- 1) No operational challenges faced by vessel while bunkering, handling and consumption of biofuel blend B20M.
- 2) Observed that for Main Engine NOx ppm was reduced by 3.75% during Loaded passage & 2.32% during Ballast Voyage as compared to VLSFO.
- 3) Reduction of 2.68% during Ballast voyage and 4.31% during loaded voyage was observed for CO2 emission (as per tank to wake). Considering life Cycle analysis as declared by the fuel supplier, the well to wake emission saving for CO2 was found to be approx.20 %.
- 4) For Auxiliary Engine the emission reduction for NOx was 12.62% and for CO2 it was 1.30%. Considering life Cycle analysis as declared by the fuel supplier, the well to wake emission saving for CO2 is found to be approximately 18 %.
- 5) For the Auxiliary Boiler there was reduction of 26.56% for NOx & reduction of 32.47% of CO2 as compared to the VLSFO, which is considerable if the percentage in savings as above for LCA is added up.

Indian Maritime Landscape: Green Initiatives



Harmonization of Biodiesel standard for adoption in maritime transportation;

- Based on the biodiesel blend trial studies, **Directorate General of Shipping, The Energy and Resources Institute and Ministry of Ports Shipping and Waterways**, took proactive initiatives in coordination with **Bureau of Indian Standard (BIS)** for harmonization of Biodiesel standard for adoption in Indian maritime sector keeping in line with ISO standard **ISO 8217: 2024**

Biofuel Bunkering : Pathway towards sustainability



भारत सरकार / GOVERNMENT OF INDIA
पत्तन, पोत परिवहन और जलमार्ग मंत्रालय
MINISTRY OF PORTS, SHIPPING AND WATERWAYS
नौवहन महानिदेशालय, मुंबई
DIRECTORATE GENERAL OF SHIPPING, MUMBAI
DGS (Engineering) Circular No. 32 of 2025

File No. - 13-22011/5/2025-ENGG – DGS, C. No: 34580		Date: 22/07/2025
Subject: Biofuel Bunkering Guidelines		
References:	(1) Merchant Shipping Notice No. 03 of 2014 (2) Merchant Shipping Notice No. 14 of 2023	
1. Background		
1.1 Increasing global emphasis on decarbonising the maritime sector has accelerated the adoption of biofuels as a sustainable alternative to conventional marine fuels. Biofuels, particularly drop-in types such as Fatty Acid Methyl Esters (FAME), Fatty Acid Ethyl Esters (FAEE), Straight Vegetable Oils (SVO), Hydrotreated Vegetable Oils (HVO), Bio-FT-diesel (bio-Fischer-Tropsch diesel) and Biomass-to-Liquid (BTL) fuels, offer considerable benefits by reducing lifecycle greenhouse gas emissions without necessitating major modifications to existing shipboard fuel systems. However, the absence of standardised national guidelines for biofuel bunkering operations in India introduces potential challenges related to safety, fuel quality assurance, environmental protection, and operational consistency.		
1.2 This proposed circular aims to bridge these gaps by establishing a clear regulatory framework for permitting, operational protocols, safety management, documentation, environmental safeguards, training requirements, and enforcement mechanisms specific to biofuel bunkering. By implementing these guidelines, the Directorate seeks to ensure safe and reliable bunkering practices, promote the use of cleaner fuels in alignment with India's environmental commitments, and support the growth of sustainable maritime infrastructure.		
1.3 These guidelines are crucial for facilitating the responsible uptake of biofuels in the shipping sector, aligning Indian practices with international conventions, and contributing to a modern, resilient, and environmentally conscious maritime ecosystem.		
1.4 The Directorate General of Shipping (DGS), recognizing the critical need to reduce greenhouse gas emissions and improve air quality in Indian coastal waters and port regions, issues this circular to enable and regulate biofuel bunkering activities in accordance with established global standards and best practices.		

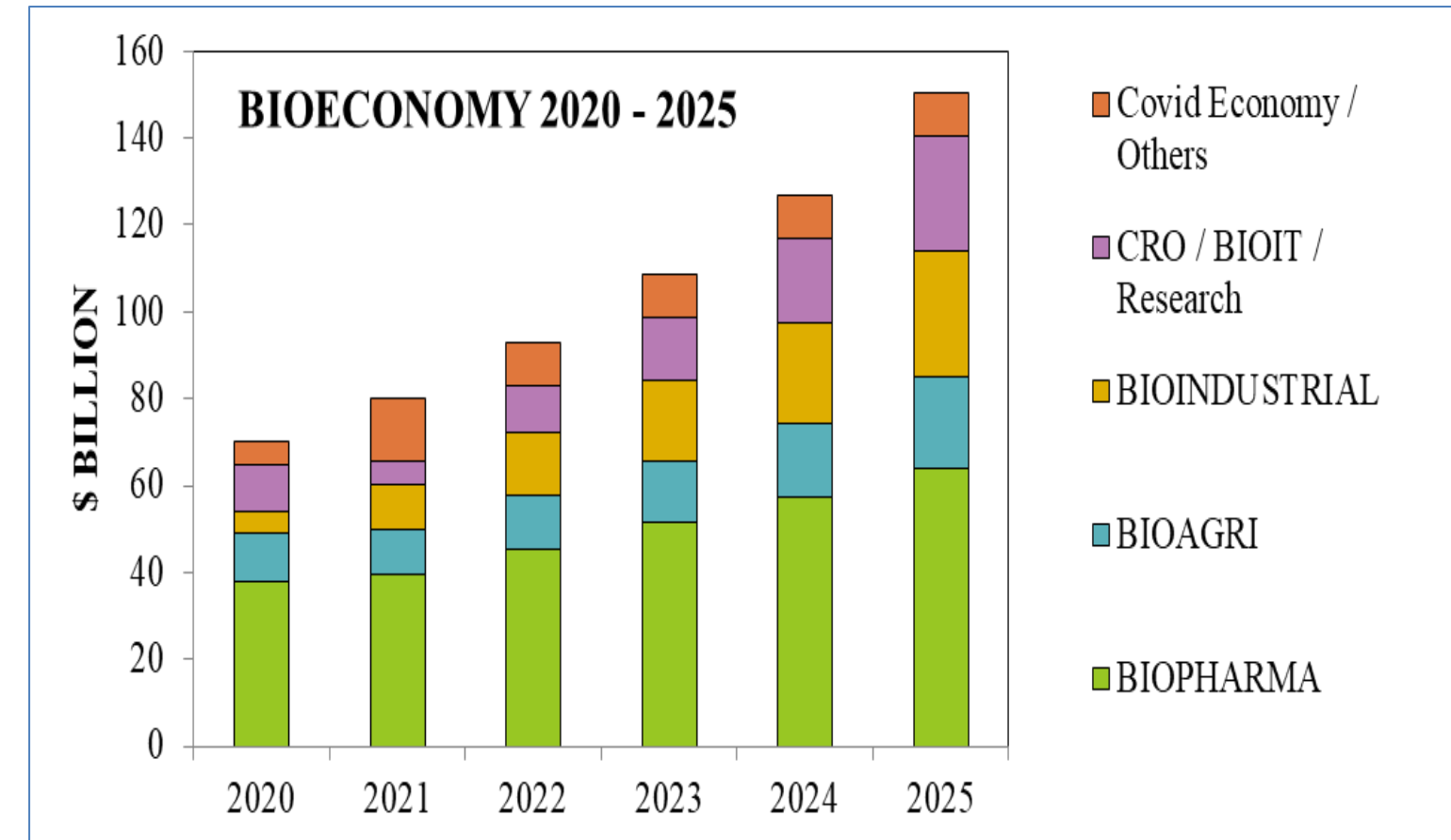
- ✓ Directorate General of Shipping, India published the biofuel bunkering guideline on 22/July/2025 that apply to all biofuel bunkering operations within Indian ports, anchorages, offshore facilities, and territorial waters,
- ✓ It covers Indian and Foreign flagged vessels receiving biofuels, as well as all entities involved in supply, storage and delivery of biofuels.

'Indian Biofuel Landscape: Scientific Advancements

Global Bioeconomy

Region / Country	Bioeconomy Value (USD Billion)	Key Sectors	Sources
India	165.7 billion USD (2024)	Biotech, Bio-agri, Bioenergy, Biopharma, Startups	PIB - BioSarathi Launch
USA	~1,000 billion USD (Estimated)	Biotech R&D, Genomics, Bio-manufacturing	Mentioned in comparison in IBER 2025 PDF
EU	~800 billion USD	Bio-based industries, Sustainable agri, Bio-innovation	Referenced in Indian Express
China	~700 billion USD (approx., 2023 Est.)	Synthetic biology, Biopharma, Bio-industrials	Cited in Entrepreneur
Brazil	~400 billion USD (includes agri-bio)	Bioenergy, Agro-biotech, Forest bioeconomy	Contextual mention in IBER 2025 PDF
Global (Overall)	>4 trillion USD (Est.)	Food systems, Renewable materials, Green energy	Highlighted as a global shift in ABLE India

India's Bioeconomy Landscape

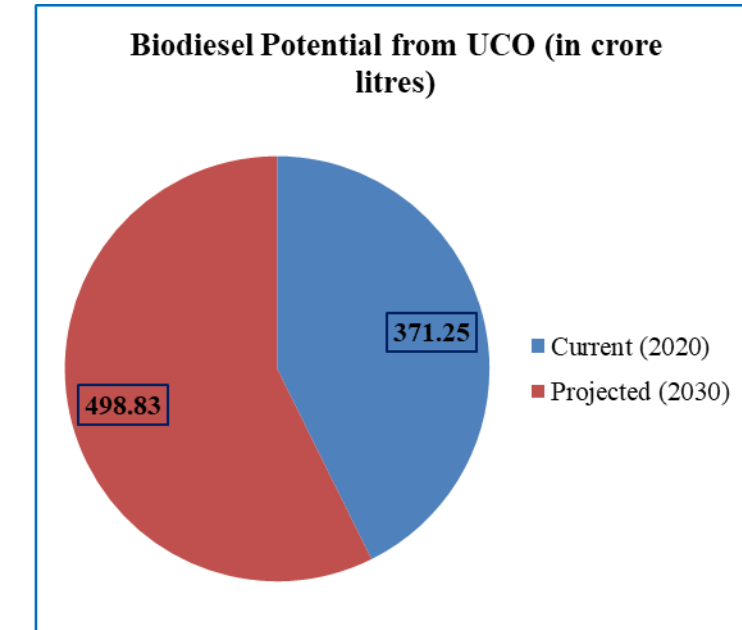
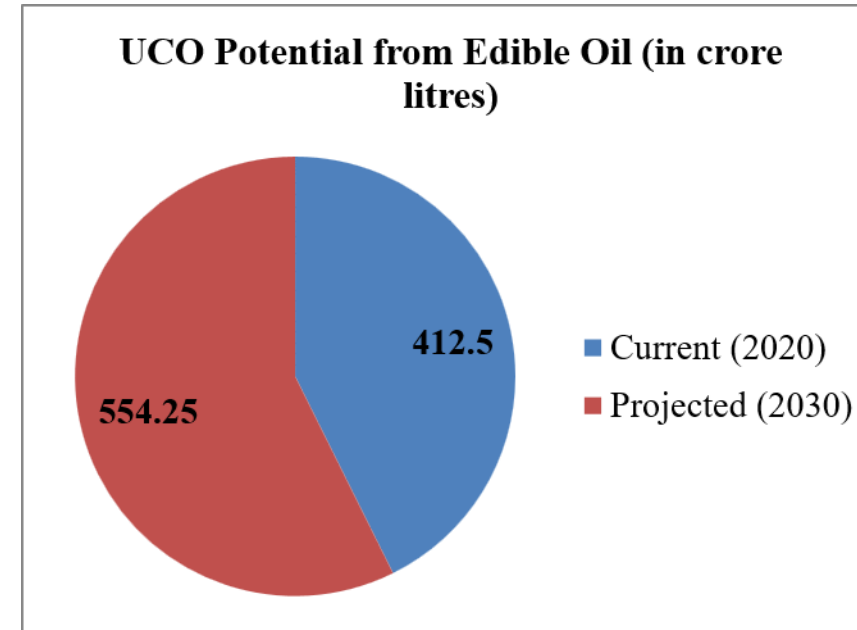


- Over last decade, India's bio-economy sector has shown exponential growth by 16-fold, starting from **\$ 10 Billion in 2014 to \$165.7 Billion in 2024**.
 - This sector is further projected to grow up to **\$300 billion by 2030**
- Driving factors;**
- Major segments contributing towards India's Bioeconomy growth are; BioPharma; Bio Agri & Bio-Industrial (Biofuels, Biochemicals, Bio-commodities), Bio-IT and Covid economy.
 - **Bio industrial sector including biofuels contributes for 47% bioeconomy growth**
 - India's vast surplus biomass availability can significantly contribute to enhance biofuel production capacity

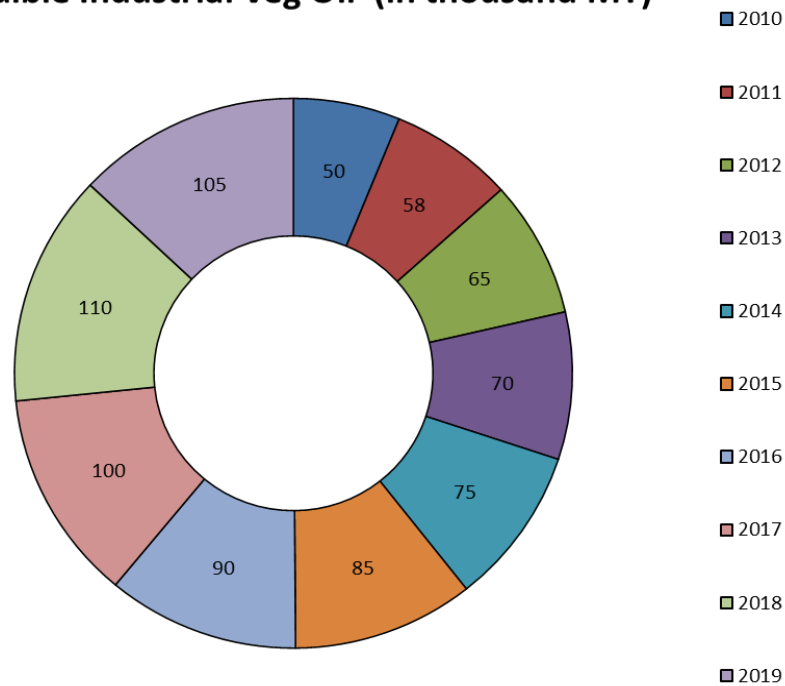
Biodiesel production and feed stock landscape

Biodiesel feedstock;

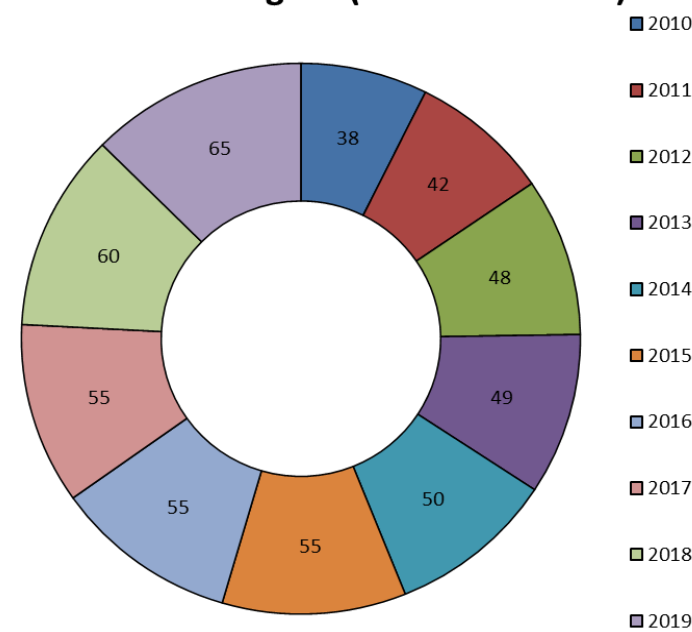
- ✓ Used Cooking Oil (UCO)
- ✓ Animal fat & tallow,
- ✓ Non-edible industrial vegetable oil
- ✓ Algae biomass
- ✓ Aquatic plant biomass



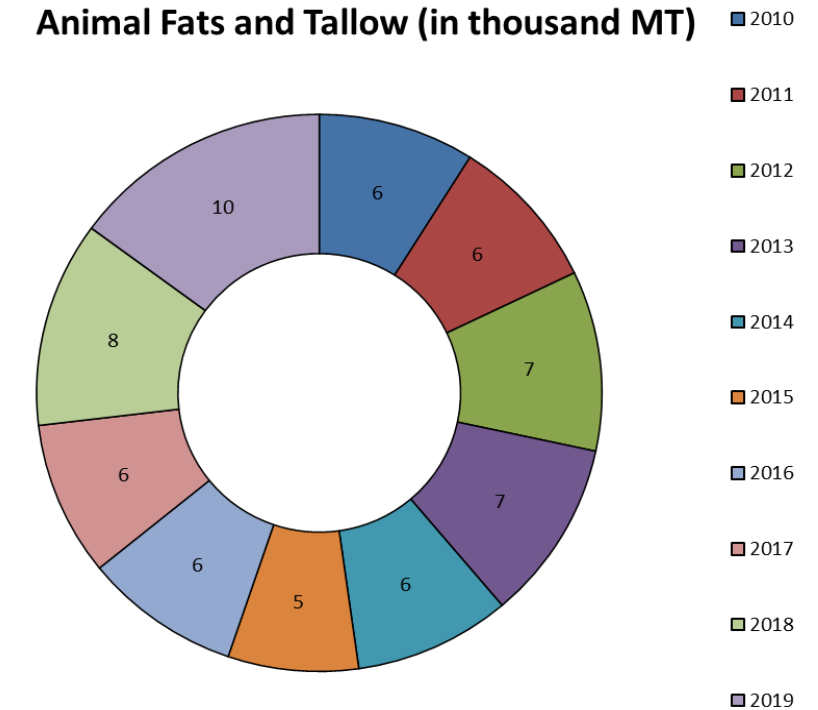
Non-Edible Industrial Veg Oil (in thousand MT)



Used Cooking Oil (in thousand MT)



Animal Fats and Tallow (in thousand MT)

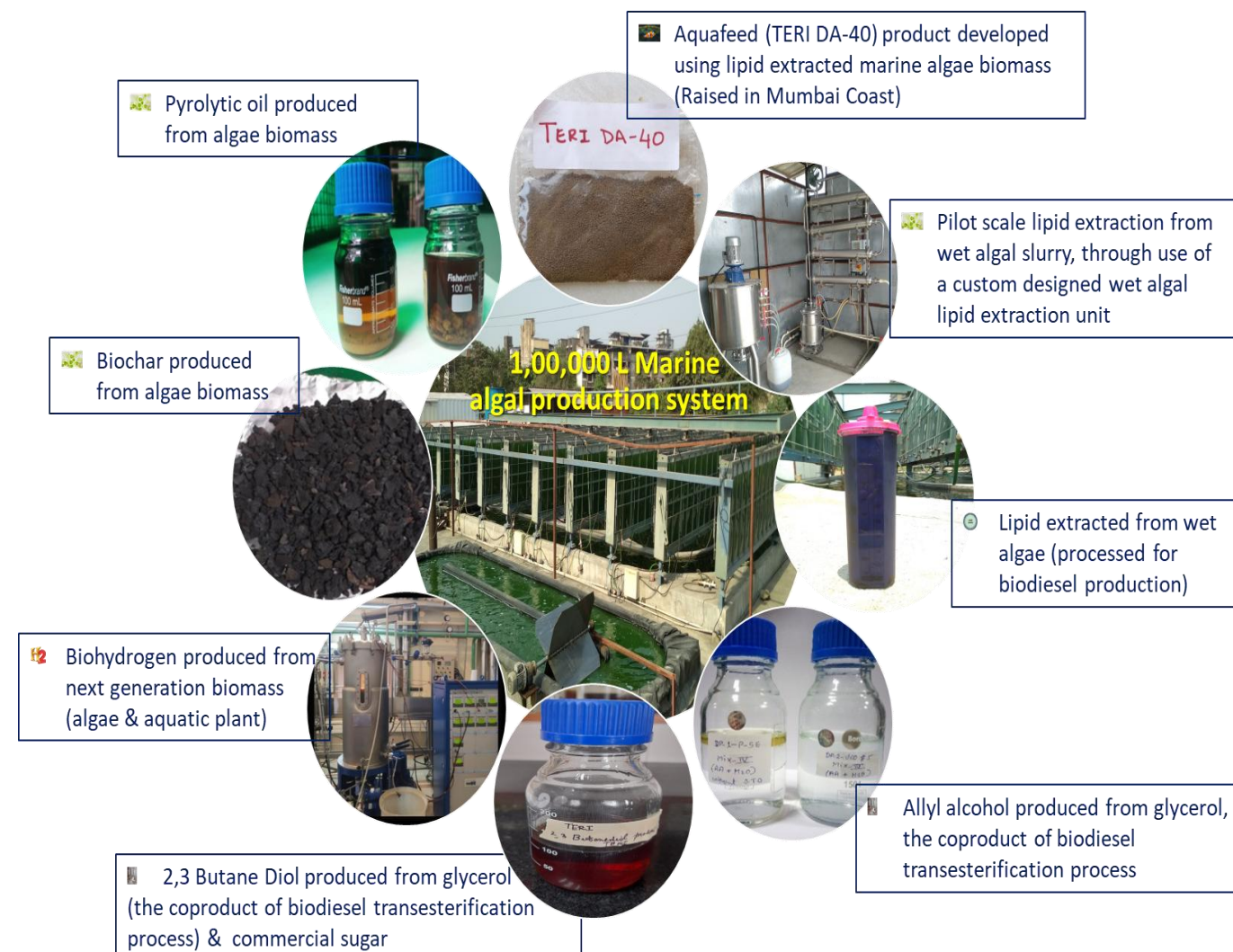


DBT-TERI Center of Excellence on Integrated production of Advanced Biofuels and bio-commodities

Scientific advancements in marine algae based advanced biofuel production

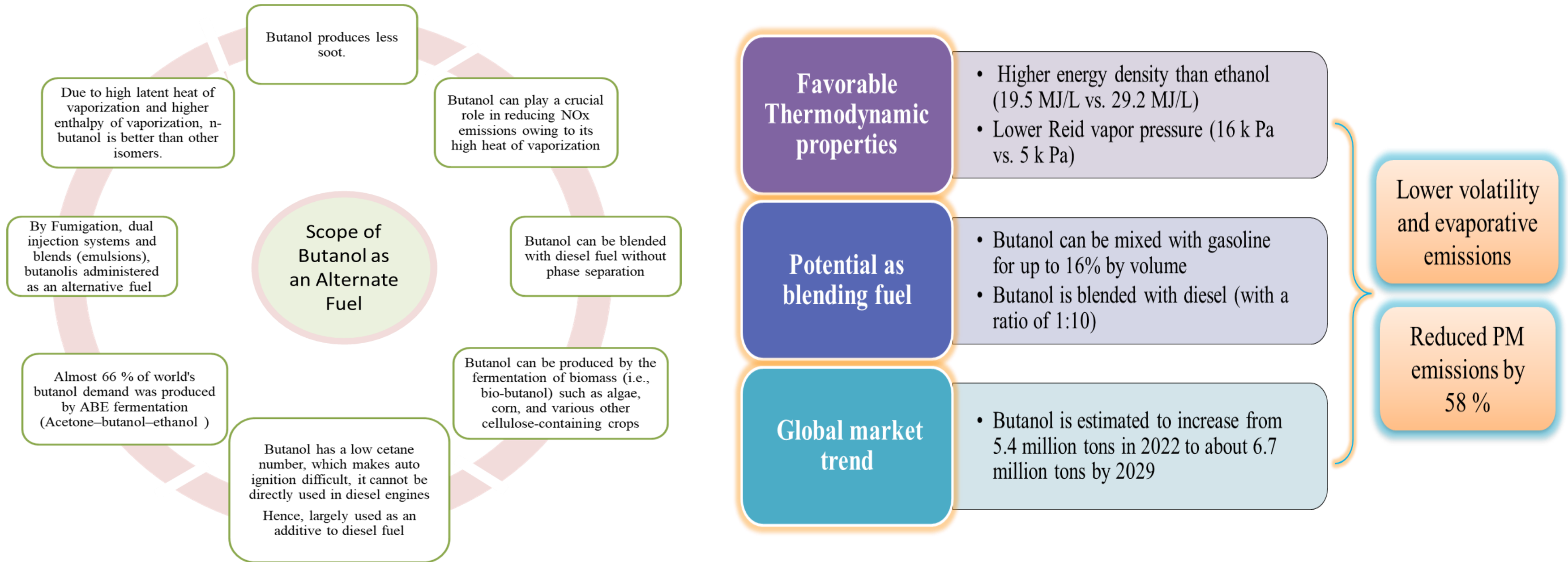


Marine algae cultivation In Mumbai coast in 100,000 liter scale specially designed photobioreactor



- 1.5 Mha land area (coastal sites across India) available for algal cultivation.
- Greta potential for marine alg2e cultivation across the coast for generation of energy algae biomass using saline water

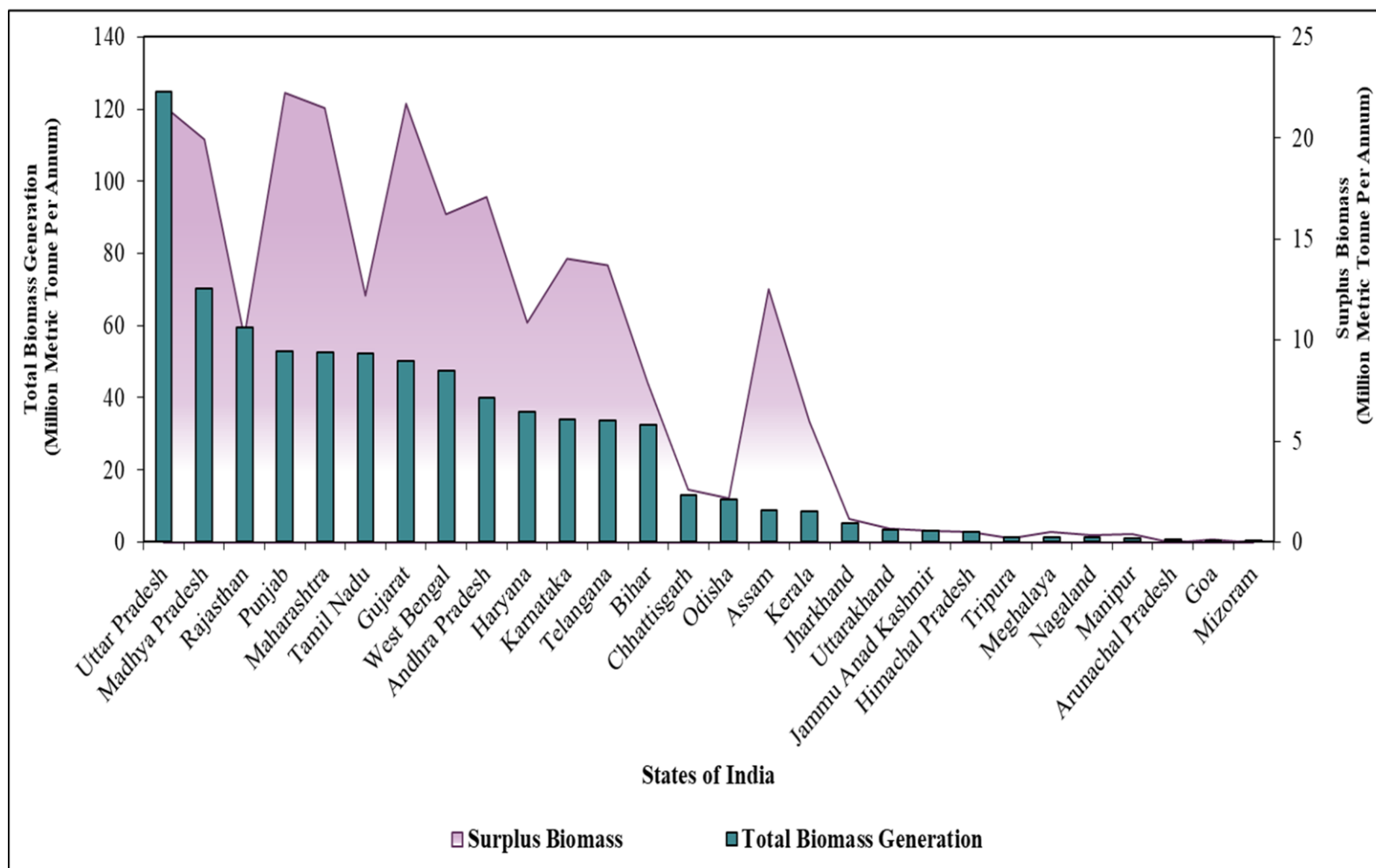
Potential of Bioa-lcohol (Biobutanol) for adoption in maritime transportation



- Biobutanol as drop-in fuel: 10% blending with marine fuel does not impact engines (secondary study data)
- Bioethanol as Drop-in fuel for maritime section: 7% blending with marine fuel does not impact engine performance beyond this it required additives (secondary data)

India's biomass landscape: Potential for contribution to India's Bioenergy basket

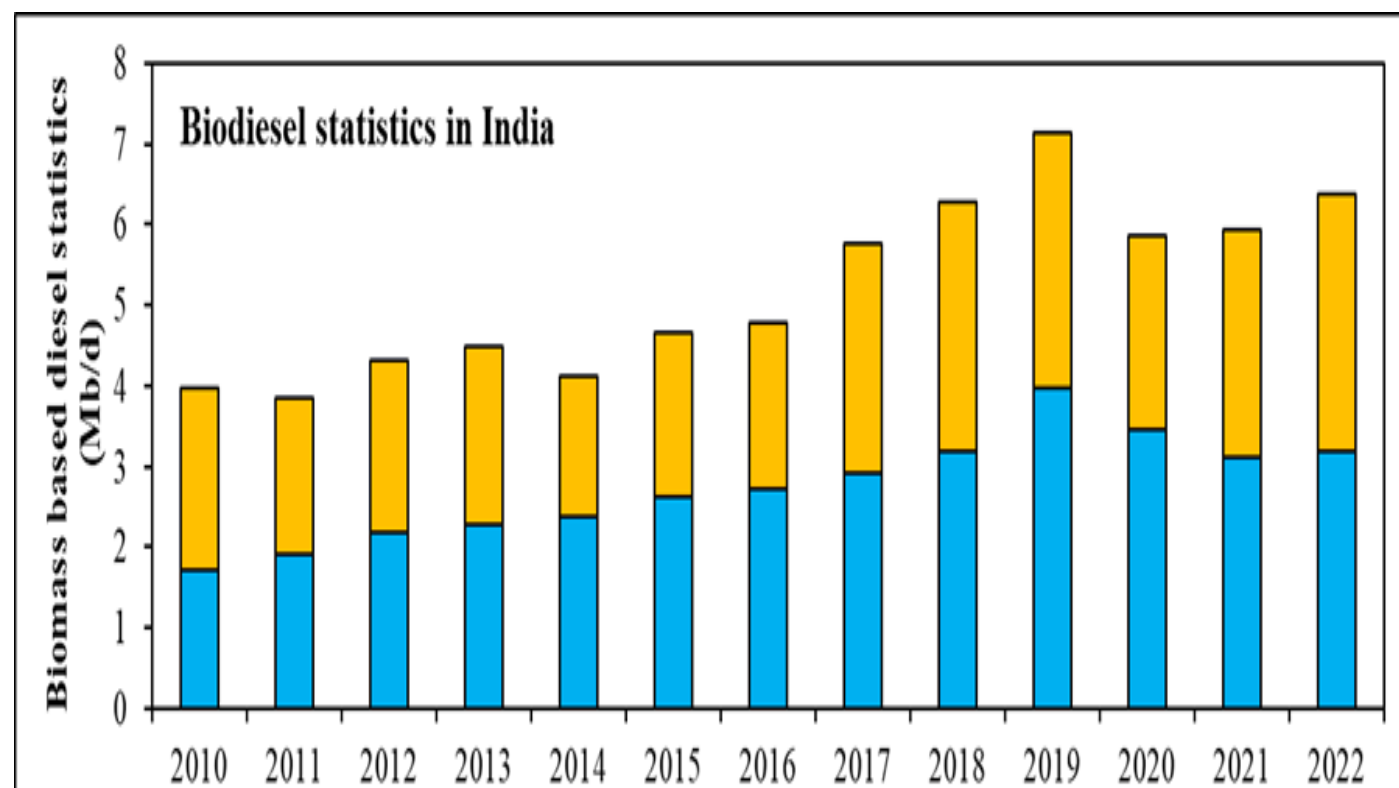
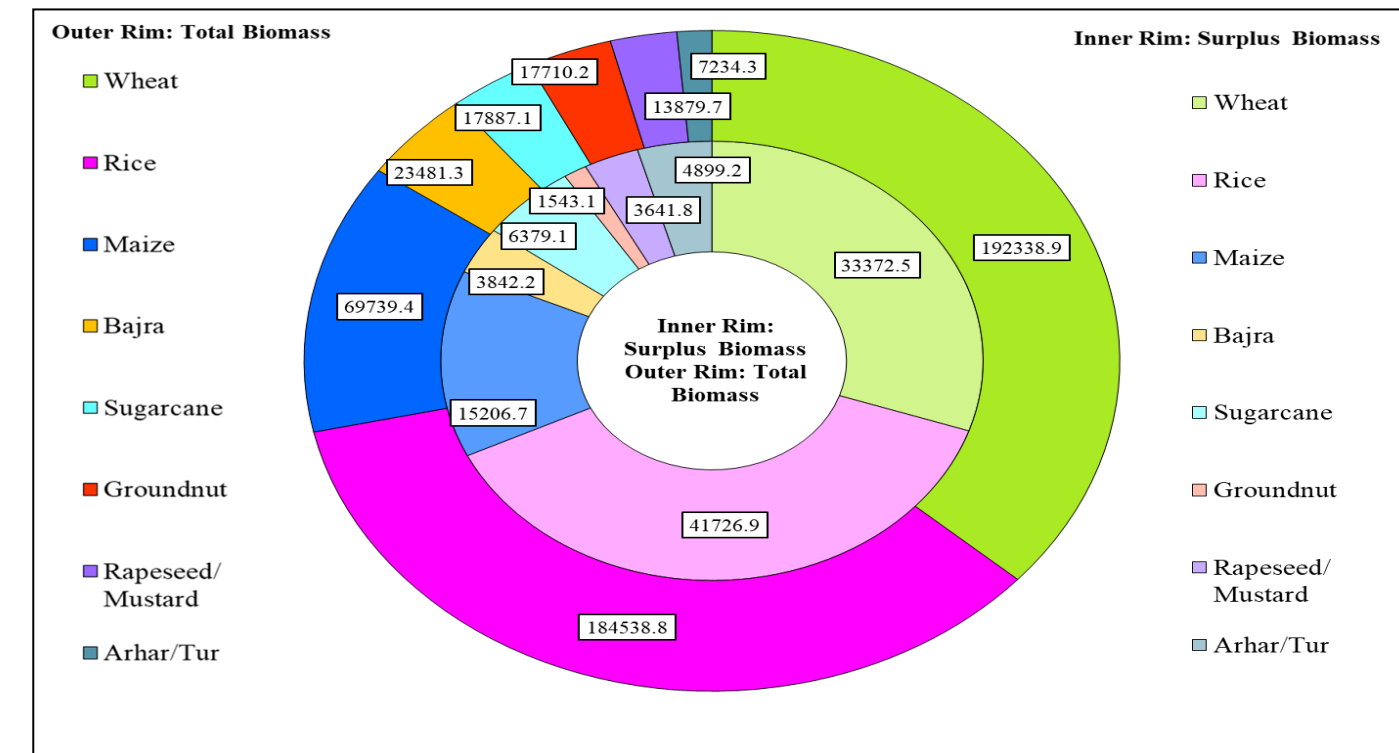
Biomass production capacity of India and availability of Surplus biomass



Biomass is available in the form of forestry waste, residue from agricultural operation, processed waste from industry, municipal/urban solid waste.

Annual Biomass production in the Country is around 750 MMT, out of which 228 MMT is surplus Biomass

TOTAL AND SURPLUS BIOMASS AVAILABLE FROM DIFFERENT CROPS IN INDIA



Bio-methanol potential for adoption in maritime sector

Feedstock

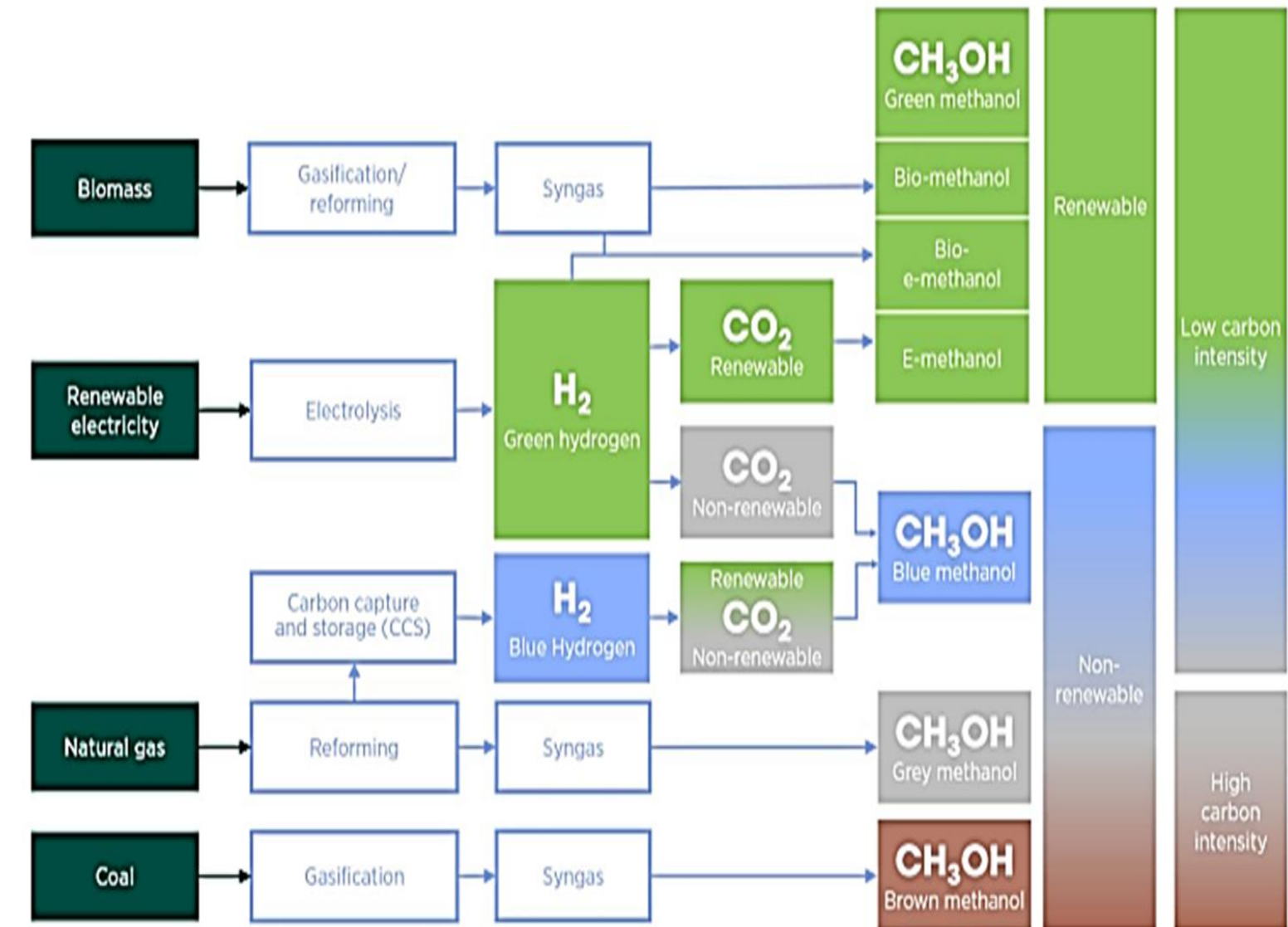
Low and carbon neutral bio-methanol from a variety of widely available renewable feedstocks such as bio-methane, municipal waste, sludge, pulp liquor and agricultural or forestry residues.

Bio-methanol production can be achieved through renewable sources like bio wastes and woods.

Production

In bio-methanol production, biomass gasification or fermentation and reforming replace fossil sources in the syngas production step. Several bio-methanol production demonstration projects and pilot plants have received attention recently in order to test the performance and competitiveness of developing an alternative low-carbon fuel.

Pathways



THANK YOU



ENERGY



AGRICULTURE



ENVIRONMENT



HABITAT



**RESOURCE
SECURITY**



CLIMATE



**HEALTH
& NUTRITION**